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## Specification

Cylinder and Device for Guiding a Material Web

The invention relates to a cylinder, as well as to a device for guiding a web of material in accordance with the preambles of claims 1 or 13.

Pairs of cylinders are frequently employed as tools for guiding webs of material, or for processing their surfaces, and are rotatably arranged with pivotable shafts and delimit a gap through which the web of material runs wherein, along a clamping line which is parallel with the shafts, it is subjected to a pressure from a cylinder which exerts a guiding effect on the web of material, or performs the processing. This pressure must be evenly distributed over the length of the clamping line for assuring processing, which is even over the width of the web and, with guiding rollers, for preventing irregularities of the slippage occurring between the rollers and the web over the width of the web, which can lead to a deformation of the web per se. Such a deformation can be the source of indexing errors when printing on the web.

An important reason for the occurrence of irregularities in the print distribution along the clamping line is the inherent deformation of the rollers because of their own weight. It is known, for example, that the forme cylinders for rotogravure printing, in particular those of a great width of an order of magnitude between 1.5 m to 4 m, have a tendency to sag under their own weight. Because of that, the pressure along the clamping line between such a forme cylinder and a counter-pressure cylinder arranged above it is reduced toward the center of the paper web.

For this reason, the counter-pressure cylinder of known rotogravure printing presses is also bent for matching the outer shape of the counter-pressure cylinder to the bending of the forme cylinder, and to distribute the pressure between the two cylinders evenly over the clamping line.

For example, a counter-pressure cylinder for a rotogravure press is known from DE 30 33 320 C2, whose shell is received, rotatably seated in rolling bearings in the area of its ends, in adjustable bearing end plates. An actuating member, which is supported on the associated bearing plate and can be actuated in the radial direction in respect to the shaft, acts on the ends of a shaft which extends through the shell and protrudes from the shell. The shell of the counter-pressure cylinder is bent by means of the actuating member, and its exterior shape is matched to the shape of a forme cylinder, which has been placed against it.

A counter-pressure cylinder, which cooperates with a forme cylinder in a rotogravure printing press, is also known from DE 100 23 205 A1. A variable matching to the forme cylinder is achieved with this counter-pressure cylinder, in that a linear drive mechanism, which is located at each of the ends of the counter-pressure cylinder between a fixed shaft and a rotating shell, acts in a vertical radial direction downward on an inner ring of a rolling bearing, while the center area of the shells is maintained rotatably, but not displaceably, on the shaft.

DE 88 08 352 U1 discloses a cylinder, whose bending can be adjusted in two planes.

USP 3,638,292 and EP 0 741 253 A2 show contact pressure rollers, which have wheels in their interior, which can be charged

with a pressure medium. These wheels are arranged on a common shaft.

USP 4,455,727 and USP 3,389,450 disclose rollers, which can be bent in two planes offset by 90° by means of actuating elements arranged in the interior.

A cylinder with means for generating an inner tension of the cylinder, and a control unit/regulator for controlling the means, and vibration sensors, are known from DE 199 63 945 C1 for controlling the means/actuating members by means of the vibrations detected by the vibration sensor.

A counter-pressure cylinder is also known from USP 4,913,051, which consists of a shaft and a shell which can be rotated around the shaft. Inflatable chambers are provided between the shaft and the shell of this counter-pressure cylinder which, after the chambers extend after being charged with pressure, cause the bending of the shell.

EP 0 331 870 A2 discloses an arrangement for the seating of cylinders, wherein journals of a cylinder are seated in two bearings arranged side-by-side in the axial direction of the cylinder. The bearings can be individually moved perpendicularly in respect to the axis of rotation by means of pressure medium cylinders in order to compensate bending, for example.

An exact guidance of a web, free of indexing errors, is made difficult, in particular in connection with rotogravure printing presses of great width, because it is extremely difficult to produce forme cylinders of great length which have an exactly constant diameter over their length. In most cases such a forme cylinder is slightly thicker in the center than at its edges. A traction force exerted between the forme cylinder and a counter-

pressure cylinder on a web passed through between them is therefore greater in the center than at the edges of the web.

As a result thereof, an uneven tension profile is generated within the paper web over its width. Since, in the course of being processed in such a press, the paper webs absorb moisture, their stretching ability increases, so that an uneven stretching of the web in accordance with the tension profile can occur. The result can be indexing errors.

Indexing errors between the center and an edge of the web could be compensated with the aid of an inlet roller, which is arranged staggered between two pressure gaps. However, in this case it is disadvantageous that on the other side of the paper web the indexing errors become even greater, and that there is a danger of a lateral drift-off of the paper web.

The present invention creates a symmetrical tension profile in the web of material, which increases toward the center or the edge areas and, in the areas of high tension, creates a change in length in the elastic range of the paper web, and in this way provides the possibility of adjusting the image points of the different colors to be imprinted, without letting the paper web drift off toward one side.

The object of the invention is based on the creation of a cylinder, as well as a device for guiding a web of material.

In accordance with the invention, this object is attained by means of the characteristics of claims 1 or 13.

The advantages to be obtained by means of the invention consist in particular in that the device makes it possible by easy means to make the effective path of the web of material, for example the paper web, variable over the width of the paper web from a fixed point, such as a guide roller located upstream of the

gap, to a fixed point located downstream of the gap. The inhomogeneity of the web tension resulting from this variability of the path length can be set in such a way that it exactly compensates an inhomogeneity caused by the thickening of the forme cylinder. In this way the stretching of the web can be made uniform over its entire width, by which a printing free of indexing errors becomes possible over the entire width of the paper web.

The shaft preferably has a device, around which the first cylinder can be rotated, two end sections and a center section, which support the first cylinder at its ends, or in the center, and at least one actuating member arranged for shifting the end sections and the center section in respect to each other in a direction which is vertical in respect to the shaft of the first cylinder, and in this way to bend the first cylinder. If the displacement direction of the actuating member forms an angle with a plane defined by the shaft of the first cylinder and the shaft of the second cylinder, the actuating member also can be sufficient for causing the curvature of the clamping line required by the invention.

The actuating direction of this at least one actuating member is preferably rotatable around the shaft of the first cylinder.

It is also possible to provide at least two actuating members, which shift the sections of the shaft in respect to each other in different directions. These directions preferably form a right angle. A total displacement in a direction, which forms an arbitrary angle with the plane of the cylinder shafts and which is a function of the amounts of the individual shifting, results from the superimposition of the shifting in these two directions.

The actuating direction of one of these two actuating members is preferably located in the plane of the shafts.

An end section projects in a preferred manner from each end of the first cylinders, and at least one of the actuating members is arranged outside of the cylinder on at least one of these end sections.

With the aid of diametrically opposed actuating members it is possible to cause a curvature of the clamping line, both with a center section which is deflected in the running direction of the web of material, as well as with a center section deflected against the running direction.

At least one of the actuating members can be a set screw.

It is also possible to design one of the actuating members as a hydraulic actuating member.

The device advantageously contains at least one bearing, for example a rolling bearing, between the first cylinder and the shaft.

Also advantageously, the cylinder has a rubber surface. The resilience of the latter makes it easier to set an even pressure distribution along the clamping line.

In an advantageous manner the actuating members are in contact with a circulating device for a coolant or a lubricant. In this case at least one seal element should be provided at the actuating members.

The second cylinder preferably is a forme cylinder.

In a particularly preferred manner, the device is a part of a rotogravure printing press.

A length of the first cylinder is quite particularly preferred to lie between 1.5 m to 4 m, so that webs of material of a corresponding width can be processed with the device.

Exemplary embodiments of the invention are represented in the drawings and will be described in greater detail below.

Shown are in:

Fig. 1, a cross section through a printing group of a rotogravure printing press in a schematic representation,

Fig. 2, a schematic front view of the cylinders of the printing group with exaggerated bending,

Fig. 3, a lateral view of a printing group,

Fig. 4, a longitudinal sectional view through a counter-pressure cylinder,

Fig. 5, a first spatial representation of a bearing of the counter-pressure cylinder,

Fig. 6, a second spatial representation of a bearing of the counter-pressure cylinder,

Fig. 7, a section line A - A through the bearing represented in Fig. 5,

Fig. 8, a lateral view of a printing group from Fig. 3,

Fig. 9, a lateral view with a modification of the printing group,

Fig. 10, a longitudinal sectional view through an alternative counter-pressure cylinder,

Fig. 11, a further longitudinal sectional view through an alternative counter-pressure cylinder,

Fig. 12, a schematic longitudinal sectional view through the alternative counter-pressure cylinder in a view from above,

Fig. 13, an actuating member in a spatial representation,

Fig. 14, an enlarged portion of the longitudinal sections represented in Figs. 10 and 11,

Fig. 15, a cross-sectional view through the counter-pressure cylinder at the level of an actuating member,

Fig. 16, the effects of different degrees of bending on a web of material having image elements,

Fig. 17, a schematic representation of a roller with a curvature in the running direction of a web of material.

A printing group, known per se, of a rotogravure printing press is schematically represented in cross section in Fig. 1. It consists of a first cylinder 06 and a second cylinder 02, which define a gap 07, through which a paper web 04 to be imprinted is conducted as the web 04 of material and is clamped along a clamping line 08 which extends vertically in respect to the plane of Fig. 1. The second cylinder 02 is provided with an engraved copper surface. The second cylinder 02 is a forme cylinder 02, which can be easily disassembled, is dipped into an ink reservoir 01, is seated in a manner not further represented here, but known per se, in a frame, not represented in Fig. 1, and is connected with a drive mechanism. A doctor blade 03 for removing excess ink taken along by the forme cylinder 02 from the ink reservoir 01 has been placed against the forme cylinder 02. The first cylinder 06 is a counter-pressure cylinder 06. It is maintained pressed against the forme cylinder 02 and is taken along by the latter by friction. Because of the effect of the contact pressure represented by an arrow, and of its own weight, the forme cylinder 02 sags in the center, as shown in an exaggerated way in Fig. 2 and in the lateral view of Fig. 3. In order to exert a uniform pressure over the entire length of the clamping line 08 from one end of the cylinders to the other, the counter-pressure cylinder 06 must follow the bending of the forme cylinder 02, which can be further seen in Fig. 2.

The counter-pressure cylinder 06 is shown in longitudinal sectional view in Fig. 4. It is rotatable around a shaft 09 and

has a hollow-cylindrical shell 11. The shell 11 has a rubber-covered surface. The shaft 09 comprises two opposite end sections 15 and a center section 13. Each one of two hollow journals 12 is connected with the shell 11, fixed against relative rotation and is rotatably maintained in a frame of the rotogravure printing press by means of bearings, for example rolling bearings. The center section 13 is extended via its end section 15 through the hollow journals 12. It supports the center area of the shell 11 via one or several bearings 14, for example rolling bearings 14, added between it and the shell 11.

A bearing bushing 16 mounted on both sides of the counter-pressure cylinder 06 on the frame for receiving the journals 12, is shown in a spatial representation in Figs. 5 and 6, and in Fig. 7 in a sectional view along the line A - A from Fig. 5. The bearing bushing 16 has a recess 17, which receives a rolling bearing supporting a journal 12 in an area of large diameter facing the counter-pressure cylinder 06, and in a narrower area facing away from the counter-pressure cylinder 06 is used for receiving an end section 15 of the center section 13 of the shaft 09, which can be seen in Fig. 6. Two connectors 18 are used as inflow or outflow for coolant or a lubricant, which flows through the counter-pressure cylinder 06 in a circuit along an intermediate space between the center section 13 of the shaft 06 on the one side, and the shell 11 and the journals 12 on the other side. The coolant or lubricant is a thermal oil which, on the one hand, is used for lubricating the counter-pressure cylinder 06 and, on the other hand, removes heat generated in the course of the operation of the counter-pressure cylinder 06 because of flexing action, and aids in the cooling of the counter-pressure cylinder 06.

A tappet 19 acting as the actuating member 19 in the form of a brass bolt 19 is furthermore provided at the bearing bushing 16 which, hydraulically displaceable, is pressed against the end journals of the center section 13 received in the bearing bushing 16. Next to the tappet 19, two set screws 21, which are arranged diametrically in respect to the center axis of the shaft 09, are provided in the bearing bushing 16 and also represent actuating members. A horizontal force is respectively exerted by them on the end journals. The tappet 19, as well as the set screws 21, are provided with sealing elements 22 at the level of a bore in the wall of the bearing bushing 16 into which they have been inserted, so as to prevent the escape of the thermal oil from the bearing bushing 16.

For adapting the counter-pressure cylinder 06 to an exterior shape of the bent forme cylinder 02, the tappet 19 exerts a pressure force on the end journal and in this way exerts a vertically directed force on the center section 13. This actuating force is transmitted via the rolling bearings 14 to the shell 11, which by means of this can be caused to rest against the sagging forme cylinder 02. The rolling bearings 14 assure that the shell 11 remains easily rotatable in spite of the considerable pressure and deformation forces. They are preferably designed as cylinder rolling bearings 14 in order to prevent the shell 11 from tilting against the center section 13, which would negatively affect the rotatability. In this case it can be seen that the radial play between the center section 13 and the cylinder-shaped shell 11, i.e. the width of the intermediate space, through which the oil flows, is dimensioned in such a way that, in case of a possibly occurring sagging of the center section 13 because of a force exerted by the action of the tappet 19, no sliding contact

between the center section and the shell 11 occurs at any point. In actual use, this distance is only a few millimeters.

Since the center section 13 only needs to transfer the force supplied by the tappet 19 to the shell 11, a rolling bearing 14 arranged in the area of the center of the shell 11 is sufficient per se. In the exemplary embodiment, two rolling bearings 14, arranged symmetrically in respect to the shell center, have been provided, whose mutual distance approximately corresponds to one third of the useful length the shell 11. This makes it possible for the shell 11 to yield a little to a pressure of the forme cylinder 02 in its center area located between the rolling bearings 14.

In addition to the vertical bending of the shell 11 caused by the tappet 19, a horizontal bending of the shell 11 in the running direction or counter to a running direction of the paper web 04 is caused by means of the set screws 21. This additional horizontal bending is used for compensating registration errors, which often occur in the course of a forme applied to the circumference of the forme cylinder 02.

As represented in Fig. 16, several image elements are imprinted on a web of material. Preferably, several first image elements have been imprinted in the axial direction side-by-side in a first printing group, and corresponding second image elements in a second printing group. The represented cylinder, in particular the counter-pressure cylinder, is a part of the second printing group. Because of bending of the counter-pressure cylinder in, or against the running direction of the web of material, the image elements of the second printing group are displaced in relation to the image elements from the first printing group opposite to, or in the running direction.

The position of the center image elements is changed in relation to the position of the two outer image elements corresponding to the bending. In another example, not represented, the web of material has at least four groups of image elements, each of which is imprinted by one printing group.

Fig. 8 shows the effects of the superimposition of the vertical force exerted by the tappet 19 and of the horizontal force exerted by the set screws 21, respectively represented in Fig. 8 by arrows identified by 19 or 21, on the end section 15 of the shaft 09. By means of the bending of the shell 11 in the running direction of the paper web 04, a curvature of the clamping line 08, also in the running direction of the paper web 04, takes place. In effect, a shifting of the center area of the shell 11 in respect to the end sections occurs in a direction which forms an angle with the plane extending through the axes of the forme cylinder 02 and the shaft 09, or the shell 11. A corresponding curvature of the clamping line 08 is the result of this.

The forces exerted by the tappet 19 and the set screw 21 respectively in the horizontal or vertical direction in Fig. 8 can, of course, be replaced by their resultant. In accordance with this it is also possible to replace the actuating members 19 and 21 with a single actuating member 19, causing a shifting in the direction of the resultant shown in Fig. 9. For this purpose the bearing bushing 16 can be mounted on the frame, for example, rotatable around the axis of the counter-pressure cylinder 06, the set screws 21 can be omitted, and the deformation of the counter-pressure cylinder 06 can be realized with only the aid of the tappet 19, whose direction can now be set.

A longitudinal sectional view through an alternative cylinder 23, namely a counter-pressure cylinder 23, is shown in a

front view in Fig. 10, and a longitudinal sectional view through the counter-pressure cylinder 23 is shown in a view from above in Fig. 11. The counter-pressure cylinder 23 is substantially comprised of a hollow shaft 24, a shell 26, which is rotatably held at its ends by means of bearings, for example rolling bearings, on the shaft 24, as well as means 27, 28, 29 for creating an inner tension in the counter-pressure cylinder 23, which are embodied as actuating members 27, 28, 29, have been introduced into the shaft 24 and act via a ring-shaped gap between the shaft 24 and the shell 26 on the shell 26. The shell 26 is provided with an exterior rubber layer. Journals of the shaft 24, which extend past the shell 26 in the axial direction, are seated in a frame, not represented, of a rotogravure printing press in bearings 43, 44, for example rolling bearings 43, 44, wherein the rolling bearing 43 is designed as a spherical roller bearing 43 for preventing the tilting of the shaft 24 in the sagging state.

A differentiation of the actuating members 27, 28, 29 is made between first actuating members 27, as well as second actuating members 28, 29. The upper longitudinal sectional view in Fig. 10 extends through the counter-pressure cylinder 23 in such a way that it intersects the first actuating members 27, while the longitudinal sectional view represented underneath it in Fig. 11 extends through the counter-pressure cylinder 23 in such a way, that it intersects the second actuating members 28, 29. The actuating members 27, 28, 29 are structurally identical and only differ in their orientation. The first actuating members 27 are arranged in a first plane and are aligned in the same direction, the second actuating members 28, 29 are arranged in a second plane, which is orthogonal in respect to the first plane, wherein

the actuating members 28 are each aligned opposite to the actuating members 29.

A longitudinal sectional view through the counter-pressure cylinder 23 is shown in a simplified way as a schematic basic sketch in Fig. 12. As can be seen in this representation, the counter-pressure cylinder 23 furthermore comprises a vibration sensor 46 and a control unit 47, which is in contact with the vibration sensor 46 and which controls the actuating members 27 shown by way of example via a hydraulic connection.

Fig. 13 shows a spatial representation of one of the actuating members 27, 28, 29, while in Fig. 14 the arrangement of such an actuating member 27, 28, 29 in the counter-pressure cylinder 23 can be seen in the form of an enlarged portion of a longitudinal sectional view through the counter-pressure cylinder 23. Finally, Fig. 15 shows a sectional view of the actuating member 27, 28, 29 arranged in the counter-pressure cylinder 23 along the line C - C drawn in Fig. 14.

The actuating members 27, 28, 29 have an angular shaft 31 with a flange 32 formed on it, which has been inserted with little play and with the interposition of a seal 33 between the flange 32 and the shaft 24 into a window of the shaft 24. The angular shape of the shaft 31 acts as a twist prevention of the actuator 27, 28, 29. A pressure cylinder 34 has been inserted into the shaft 31, in whose chamber a piston 36 can be shifted by the action of hydraulic fluid supplied via a hydraulic connector 37. The hydraulic connector 37 is mounted in one of two bores 48 of the hydraulic cylinder, which terminate in the chamber. In actual use, the second bore 48, shown unoccupied in Fig. 15, is provided with a blind plug or a second hydraulic connector 37, from which a pipe line leads to an adjoining actuating member. In this way the

actuating members 27, 28, 29, can be combined into several groups of interconnected actuating members, which are charged with an identical pressure, which can be independently controlled from group to group.

Each one of the actuating members 27, 28, 29 has been combined by wheels 38 into a module, which can be removed as a unit.

In the embodiment represented, the piston 36 has two wheels 38, which can be rotated around a common shaft 35 and together constitute a double roller acting as a rolling bearing, which, with the piston 36 extended, roll off on a bearing race 39 introduced between the shell 26 and the shaft 24. The shaft 35 is connected with the actuating member 27, 28, 29 via a joint 40, which is embodied as an adjusting bearing 40, for example. Each actuating member 27, 28, 29 has its own, independently movable shaft 35. These shafts 35 are not connected with each other. In the present example, the shaft 35 supports two wheels 38 seated on rolling bearings. In all exemplary embodiments, the circumference of the wheels lies completely outside of the axis of rotation of the shell 26.

When the actuating members 27 are charged with pressure, they cause a bending of the center area downward in Fig. 10, or transversely in respect to the plane of Fig. 11. By charging the actuating members 28 or 29 with pressure, it is possible to obtain bending selectively toward the top or the bottom in Fig. 11 or, with simultaneous charging of the actuating members 27, in a direction obliquely oriented in respect to the planes of intersection of Figs. 10 and 11. It is also possible to simultaneously charge the oppositely oriented actuating member 27,

28, which does not necessarily lead to bending of the shell 26, but to a distortion of its cross section into an ellipse.

As can be seen in Figs. 10 and 11, the shaft 24 has inlets or outlets 41 for a thermal oil on both sides, which is used as a coolant or lubricant for the counter-pressure cylinder 23. Here, the thermal oil flows through lines 42 in the ring-shaped gap between the shell 26 and the shaft 24. If flows through the counter-pressure cylinder 23 in this gap over its entire length and leaves it via corresponding lines 42 and inlets or outlets 41 at its opposite side. The wheels 38 of the actuating members 27, 28, 29 are lubricated in this way on the one hand, and on the other hand the thermal oil removes frictional heat, which is generated as a result of flexing action of the shell 26 occurring on an outer rubber layer of the shell 26, as well as on account of friction.

During operation of the rotogravure printing press, the shell 26 of the counter-pressure cylinder 23 rotates around the shaft 24. For generating a uniform pressure over a length of the clamping line 08 it is necessary to match the counter-pressure cylinder 23 to an outer shape of the forme cylinder 02. This is done by means of the actuating members 27, 28, 29. By charging them with hydraulic pressure, the pistons 36 are extended and the wheels 38 press against the shell 26, which results in a shifting of the shell 26 in respect to the shaft 24. By means of this the outer shape of the shell 26 can be adapted to bending or other irregularities in the shape of the forme cylinder 02, and the desired pressure distribution in the clamping lines 08 can be realized. Above all, the right-angled arrangement of the first actuating members 27 and the second actuating members 28, 29 permits bending of the shell 26 at any arbitrary angle in respect

to a plane extending through the axes of the counter-pressure cylinder 23 and the forme cylinder 02 placed against it, and therefore the setting of a path length of the web, variable in the direction of the width of the web 04, between two fixed points, such as for example guide rollers on both sides of the gap 07.

As already mentioned, during operation of the counter-pressure cylinder 23, the shell 26 rotates around the shaft 24. In the course of this, vibrations of the counter-pressure cylinder 23 occur, which can build up to greater amounts if the rotation frequency of the shell 26, or a whole number multiple thereof, corresponds to a resonance frequency of the counter-pressure cylinder 23. The strength of these vibrations is measured by the vibration sensor 46, and the result of the measurement is transmitted to the control unit 47. If the control unit 47 notes an increase of the strength of the vibrations past a predetermined threshold value, which indicates the presence of a resonance, it hydraulically triggers the actuating members 27, 28, 29. When these push against the shell 26, they cause bending of the shell 26 and, to a reduced amount, also of the shaft 24. Corresponding to the hydraulic pressure supplied by the control unit 47, a contact pressure varies, with which respective pistons 36 of each actuating member 27, 28, 29 press against the shell 26, and along with it the inner tension of the shell 26 and the shaft 24 varies. An increase of the pressure corresponds to stiffening the counter-pressure cylinder 23, and therefore an increase in its resonance frequency. If, by changing the contact pressure, the resonance frequency is changed to such an extent that it no longer agrees with the frequency of rotation of the shell 26, the undesired vibrations are reduced.

## List of Reference Symbols

- 01 Ink reservoir
- 02 Cylinder, second, forme cylinder
- 03 Doctor blade
- 04 Web of material, paper web
- 05 -
- 06 Cylinder, first, counter-pressure cylinder, roller
- 07 Gap
- 08 Clamping line
- 09 Shaft
- 10 -
- 11 Shell
- 12 Journal
- 13 Center section
- 14 Bearing, rolling bearing, cylinder rolling bearing
- 15 End section
- 16 Bearing bushing
- 17 Recess
- 18 Connector
- 19 Actuating member, tappet, brass bolt
- 20 -
- 21 Actuating member, set screw
- 22 Sealing element
- 23 Cylinder, counter-pressure cylinder
- 24 Shaft
- 25 -
- 26 Shell
- 27 Actuating member, means

28       Actuating member, means  
29       Actuating member, means  
30       -  
31       Shaft  
32       Flange  
33       Seal  
34       Pressure cylinder  
35       Shaft  
36       Piston  
37       Hydraulic connector  
38       Wheel  
39       Bearing race  
40       Joint, adjusting bearing  
41       Inlet/outlet  
42       Line  
43       Bearing, rolling bearing, spherical roller bearing  
44       Bearing, rolling bearing  
45       -  
46       Vibration sensor  
47       Control unit  
48       Bore